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ABSTRACT

In 1986, the International Council fo Scientific Unions (ICSU) launched the International Geosphere-Biosphere Programme: A Study of Global Change (IGBP). The IGBP seeks to focus attention on the physical, chemical, and biological processes which contribute to understanding the components of the Earth as a system. The research topics presented in this report focus on the human dimensions of global environmental change and on approaches to understanding the relationship between human activity and global change. Following an article on the background of the program and an overview, several topics are discussed including: "The Social Dimension of Resource Use"; "Assessment and Perception of Environmental Change"; and "Impact of Institutional Mechanisms on the Environment." In conclusion, the workshop participants strongly urged international cooperation in this field. An appendix includes lists of the Chinese and American participants in the Human Dimensions of Global Environmental Change workshop which was held in May, 1988, at Peking University. (CW)

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Human Dimensions of Global Environmental Change: Proposals for Research

Report of a Chinese – U.S. Workshop 12 – 16 May 1988

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Report of a

Chinese – U.S. Workshop

12 – 16 May 1988

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Human Dimensions of Global Environmental Change:
Proposals for Research
Report of a Chinese – U.S. Workshop

1. Background

In September 1986, the International Council of Scientific Unions (ICSU) launched the International Geosphere – Biosphere Programme: A Study of Global Change (IGBP), which will begin full scale operations in 1990 and will continue throughout the decade of the nineteen-nineties. The IGBP, as originally conceived, focused attention on the physical, chemical, and biological processes which contribute to understanding the components of the Earth as a system. The research topics presented in this report focus on the human dimensions of global environmental change and on approaches to understanding the relationship between human activity and global change.

The report is a product of a joint Chinese – U.S. Workshop on the Human Dimensions of Global Environmental Change that was held in Beijing from the twelfth through the sixteenth of May 1988.[1] The workshop was co-chaired by Professors Tang Xiaoyan, Peking University, and Harold K. Jacobson, University of Michigan. It included participants from the natural and social sciences. A list of Chinese and U.S. participants is attached. The workshop was jointly sponsored by the Chinese State Education Commission and the U.S. National Science Foundation under the

1. The report draws heavily on and in some instances directly appropriates sections of papers presented at the workshop or material prepared by workshop participants. Although Tang Xiaoyan and Harold K. Jacobson assume full responsibility for the report, the true authors are the participants in the workshop. U.S. participation in the workshop was supported by NSF Grant INT 8813343 to the Center for Political Studies, Institute for Social Research, the University of Michigan. Any opinions, findings, and conclusions or recommendations expressed in the report are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Protocol on Cooperation in the Basic Sciences. The workshop was one of the preparatory steps that have been taken toward launching an international research program on the human dimensions of global change.[2] This report was prepared for presentation to: the General Assembly of the International Council of Scientific Unions at its meeting in Beijing in September 1988; the September 1988 Tokyo International Symposium on Human Response to Global Change; and other national and international fora and organizations concerned with human dimensions of global change.

Workshop participants concluded that without a full exploration of the human dimensions of global environmental change, the conclusions sought from the International Geosphere – Biosphere Programme: A Study of Global Change would be incomplete. Increasingly, human activities have been found to be the source of significant impacts on the geosphere and the biosphere. Among these human activities are the expansion of agriculture, burning of fossil fuels, destruction of forests, depletion of water supplies, and the release of chemicals into the environment. The growth rate of these environmentally important activities, however, and hence the pace at which human beings affect the Earth system, has not been clearly charted. Current trends cannot simply be projected into the future, for the dynamics of environmentally-critical human activities are subject to change, partly as a result of conscious attempts to moderate the human impact of global change.

Consequently, the workshop recommended — as have other organizations, symposia, and workshops — that an international research program dealing with the human dimensions of global environmental change should be designed to complement or become part of the IGBP. Of

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2. Reports of other steps include: David Braybrooke and Gilles Paquet, Human Dimensions of Global Change: The Challenge to the Humanities and the Social Sciences (Ottawa, Ontario: The Royal Society of Canada, 1987); Harold K. Jacobson and Cheryl Shanks, Report of the Ann Arbor Workshop on an International Social Science Research Program on Global Change (Ann Arbor, MI: Institute for Social Research, 1987); International Federation of Insitutes for Advanced Studies, Human Response to Global Change: Prospectus for an International Programme, 2nd Edition (Toronto: The HRGCP Secretariat, 1988); William C. Clark, The Human Dimensions of Global Change: Report of the Human Components Working Group (Washington, D.C.: National Research Council, 1988); and Roger Kasperson Proposal for a Research Program on Social Processes and Earth Transformation (New York: Social Science Research Council, 1988)

particular concern in the design of such a program are those issues, which for both developing and developed countries, have primarily local, regional, or national effects, but which ultimately have global consequences.

Drawing on research conducted in China and the United States, workshop participants presented papers on: demographic change and urbanization; technological change; economic growth, social development, and environmental protection; resource use; risk assessment; attitudes and behavior toward the environment; the consequences for the environment of institutional mechanisms, including governmental regulation and markets; the role of law in modifying and regulating behavior; and the data requirements of an international research program on the human dimensions of global environmental change.

Based on the discussion of these papers, the workshop proposed three broad topics for inclusion in an international research program on the human dimensions of global environmental change: (1) the social dimensions of resource use; (2) the assessment and perception of environmental change; and (3) the impact of institutional mechanisms and legal systems on the environment. The next section of this report discusses possible contributions by social science research to the study of global change. The following sections outline and explore essential aspects of each of three broad topics identified as potential research areas by the Chinese – U.S. Workshop.

2. Overview

We, the peoples of the world, face a new responsibility for our global future. Through our economic and technological activity, we are now contributing to significant global changes on the Earth within the span of a few human generations. We have become part of the Earth System, and one of the forces for Earth change.[3]

Scientific advances in recent years have yielded dramatic new knowledge about the Earth. From the perspective of space to the core of the Earth, science and technology are providing us with information about the planet we inhabit. A startling aspect of this information is the extent to which human activity affects the earth habitat in ways unprecedented in human history. Human activity now clearly affects the composition of the atmosphere and the ecology of the land. Human beings not only effect global change, however; they must live with the results. Some of the consequences of human activity, as yet incompletely understood, still suggest urgency to studies of the global system.

To understand the changes caused by both natural and human processes, a program for the study of global change in the geosphere – biosphere, the IGBP (International Geosphere – Biosphere Program) was conceived. Launched in 1986 by the International Council of Scientific Unions (ICSU), the IGBP reflects an awareness on the part of a community of scientists in the geosciences and the biological sciences that attention must be given in research to the global relationships among the Earth's components. Efforts to understand the workings of the Earth as a system are at the core of the IGBP.

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3. USA, National Aeronautics and Space Administration, Earth System Science: Overview: A Program for Global Change (Washington, D.C.: NASA, 1986), front inside jacket.

The need to understand, and to respond to human activity as a part of the Earth system has been an integral part of the scientific justification for the IGBP; the specific ways in which we might study human behavior and its effects on global environmental change have yet to be spelled out. This reflects the primary focus of the IGBP — the study of Earth processes from the perspective of the biological and earth sciences. The methodologies and theories relevant to the study of human behavior are primarily the province of social science, and it is to social scientists that we must look to define the research necessary to understand the human dimensions of the Earth system.

One of several efforts to define research activities that would contribute to understanding the human dimensions of global change, the May 1988 workshop held in Beijing between U.S. and Chinese scientists defined three broad topics that reflect the contribution social science can, and must, make if the study of global change is to reflect completely the dimensions of human involvement in the Earth system. Recognizing that observational and monitoring techniques, sophisticated space-based measurement systems, and remote sensing provide many tools for measuring human impact on the environment, workshop participants noted that the dynamics of population, or more compellingly, the "tectonics of population," particularly as they relate to resource use, must be factored into any assessment of global change. Of the goals of the IGBP, modeling and predictive efforts especially require as sophisticated a contribution from demography as is available. Much as the revelations of recent advances in plate-tectonic theory have shaped our understanding of the Earth's crustal features, projections of world population growth and distribution must guide our inquiry into the potential impact of human activity on the Earth system. The demographics of population growth cannot be ignored, for by sheer number and by distribution, expected to increasingly be centered in urban areas, the human population of this planet will have profound effects on the habitability of the Earth.

To address how such effects, whether environmentally constructive or destructive, might be perceived, evaluated, and responded to by humankind, social science must also contribute to the study of global change by defining research which will illuminate the process by which human attitudes and perceptions are formed and the nature of institutional response. Many of the documents describing the IGBP and contributing national programs reflect an implicit belief that once scientific endeavors have produced valid data and informed analysis, decision making will become more effective, and social, governmental, and legal responses to global environmental change will incorporate a sophistication and paramount concern for the health of the planet.

While the potential effects of some global processes such as depletion of the ozone layer, global warming, or desertification are compelling, the drive for economic growth is also compelling. Prosperity is a common goal, and those concerned about global change must ask that social scientists participate in defining what motivates human response to environmental change or in discovering which institutions, governmental, and legal mechanisms have proven effective in managing global environmental change and why they were effective; in constructing a framework through which the study of these questions can be pursued; and in addressing the questions of cost-benefit which will certainly arise when scientific data is more readily available and employed by decisions makers. To assume that we can predict human behavior without further research on these questions is wrong, and to proceed on that assumption would mean that a crucial part of the research needed to understand and to respond to global change would be lacking at the end of this decade-long effort.

To illustrate more directly the need for combining social science and natural/physical sciences in addressing questions which are of global concern, the question of stratospheric ozone may be a useful example to consider. The state of the ozone layer, which protects the Earth from harmful solar ultraviolet radiation, has captured the attention of both the scientific community and the general public. Recent investigation suggests that the chemistry of the global atmosphere

is more sensitive than was predicted by quantitative models. While further study is needed to understand what is causing the depletion of the ozone layer, and to determine whether the question is one of spatial and temporal variability not previously understood, there is enough information available to raise questions about the effects on the ozone layer of chemicals released into the atmosphere through industrial activity.

There is a compelling quality to the ozone question. Scientists concerned about depletion of the ozone layer marshaled forces to investigate the physical parameters and to report the preliminary results to governments, to the media, and to the public. Efforts are underway to construct a legal framework, including an international protocol which has already been prepared, which would limit production of those chemicals known to be most destructive of stratospheric ozone. Some fundamental questions remain to be framed, however, and until the missing link between our scientific understanding and our ability to respond to such global changes through institutional mechanisms is defined, the process of understanding and managing the effects of global change will be incomplete. The missing link, in this case, is the contribution which social science can make through research on what will motivate people to make choices in their personal lives, in industry, in government and law, and in all the aspects of human life which involve selecting from among options with known environmental impact. Nor can the economic impact of these choices be ignored, for we know too little about the effectiveness of institutional mechanisms such as markets in determining human behavior with respect to the environment. Simply to give policy makers the findings of scientific research with recommendations to limit the production of certain chemicals ignores forces which are major motivators of human behavior — economic, political, and social realities which compete with environmental concerns for the attention of policy makers. This is where we need to conduct research on the role of risk assessment, the influence of the media, the evolution of law and

international treaties, the development and use of economic analyses (cost-benefit) in decision making, the dynamics of human attitudes and perceptions.

Perhaps the assumptions made by scientists modeling the physical aspects of the atmosphere about human influences such as projected time sequences for burning of fossil fuels, industrialization patterns or changes in land use are inaccurate or even dangerously inaccurate. All human activities known to affect the Earth system involve variables which cannot necessarily be predicted in a linear fashion. Without the insertion of sophisticated social science-based models, data, and forecasts, the path to understanding the global environmental changes brought about by human activity and the options and consequences of actions to address these changes may take a misleading turn or run into a dead-end.

There are premonitions that the potential for global environmental changes such as massive desertification and deforestation, global warming and associated sea-level rise, and depletion of the Earth's energy and mineral resources exists within a time-frame of decades to centuries, yet there is still considerable scientific uncertainty about the causes, whether natural or anthropogenic, of these changes and about their effects. What effect will the reduction of plant and animal diversity through clearing of tropical forests have for life on Earth? What does the seemingly inexorable process of desertification mean for the world's hydrologic system? If production of "greenhouse gases," both from natural processes and from human activity, continues as projected, what implications should be drawn for human settlements?

Clearly, more scientific data and analyses are needed to describe the relationships among these processes taking place on Earth. Even with incomplete scientific information, however, a sense of urgency is developing about the potential impact of many of these processes if they are left unattended. The treatment of subjective factors such as perception of problems by individuals, through mobilization of groups and on to authoritative decisions of governments and

international institutions is critical in bridging the gap between scientific uncertainty and the need for action. Social science can provide insight into subjective attitudes toward important environmental concerns. Questions which merit study include whether awareness of environmental problems grows most rapidly where individuals suffer acute loss from environmental degradation. This might suggest some conclusions about the importance of the speed of change of environmental conditions and human response. The role of the mass media should be studied, as should the commitment to environmentally sound practices once such practices start to have costs.

One question which might be asked is why courses of action that seem rational and efficient are not being followed. We can assume that obstacles might be economic, ideological, or cognitive, but we do not understand them very well. One such example of a cognitive obstacle to rational resource management which is not well understood is the impact of risk perception. What are the different ways in which experts and the lay population estimate the risk involved in certain situations? We also need to explore whether economic penalties and incentives are more effective than legal regulation, and whether legal regimes which conflict with each other cause more problems than they solve. What can we say about these questions as they relate to the future of the global environment? What is the research which will help answer these questions?

These are but a few of the questions which demand more complete answers. Efforts to obtain a full understanding of the process of global change and our capacity and will to manage such change must incorporate the research necessary to describe and project the nature, extent, and consequences of human activity. In the following sections, some of the research topics proposed above will be described in more detail.

3. The Social Dimensions of Resource Use

The most compelling reasons for studying resource use as part of research on the human dimensions of global environmental change were forcefully described in ICSU's planning document for IGBP:

> *The dominant changes that affect the environment and the course of life on Earth are natural ones, induced by such inexorable forces as natural selection, the shifting of winds and rivers, changing inputs from the Sun, the turbulent dynamics of the atmosphere and oceans, the drifting of the continental plates, the building of mountains, and the expansion and contraction of ice masses. But imposed on these is now another set of changes, more recent and immediate in consequence, that are the clear result of human activities. Our uses of energy and practices of intensive farming and technology have altered the albedo of the Earth, the composition of soil and waters, the chemistry of the air, the areas of forests, the diversity of plant and animal species, and the balance of global ecosystem.*[4]

In sum, human use of the Earth and its resources has become a significant force in global change.

Although the International Geosphere-Biosphere Programme is a basic science research program, its ultimate purpose is practical. As stated in the ICSU planning document " . . . an improved description and a deeper understanding of the planet on which we live will improve the reliability of warnings of significant global change and will provide the bases for more rational management of resources."[5] More rational management of resources, however, will not be an automatic result of improved understanding of natural processes. Improved understanding of the economic and social implications of alternative policies affecting resource uses will be needed to facilitate sound human decisions to avoid impending adverse global environmental changes and mitigate the adverse effects of changes that cannot be avoided.

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4. ICSU, The International Geosphere-Biosphere Programme: A Study of Global Change (Paris:ICSU, 1986), p. 1.

5. ICSU, The International Geosphere-Biosphere Program, p. 2.

An exploration of the social dimensions of resource use would be a crucial foundation for gaining such an improved understanding. This would involve an analysis of two related issues: population characteristics; and population, economic growth, and technology as interacting forces affecting resource use.

a. Population Characteristics

Population is a basic driving force in human-caused global environmental change. Population characteristics influence economic, social, and technological changes and are, in turn, affected by them. These interactive processes determine land use, water use, air use, and the use of other renewable and non-renewable resources and in turn affect the geosphere and biosphere.

Barring catastrophes on an historically unparalleled scale, in the next half century the earth's population will double, even though fertility rates will continue to drop and population growth rates will continue to fall. The increasing numbers of people on earth will have a direct effect on future environmental changes.

As important as the growing number of people is their location, or the tectonics of population growth. The shift of population from rural to urban locations is happening even faster than the growth in the total population. This shifting structure will be a crucial determinant of the environmental challenges of the future.

Some of the parameters of urban areas that can be measured suggest that concentrations of population in urban settlements may have some significant implications for the Earth system. Different human settlements have different albedo, which may affect the global energy and water balance. For instance, cities are warmer than rural areas due to the heat island effect. Wind speed in cities is less than in rural areas because of surface roughness. Precipitation, thunderstorms, and hailstones are more frequent in cities. Urbanization has the potential of affecting global

hydrologic patterns through demand, supply, and use or conservation of scarce water resources. Urban areas have been shown to use much more energy than rural areas. The urban energy metabolism is therefore much higher than in rural areas because of the concentration of industries in and around cities. It is this higher urban metabolism, combined with the increasing urban population, that may produce a nonlinear effect on the environment.

The size, rate of growth, age composition, and distribution by region and size of city are all significant characteristics of the population that affect linkages among city size, resource use, resource productivity, and environmental conditions. To understand better such linkages and to increase the accuracy of demographic forecasting, research should be conducted on such characteristics of human populations as the determinants of fertility, particularly for rural populations and rural-urban migrants; the determinants of migration from rural areas to towns and cities; and the consequences of these demographic processes on the age composition of rural and urban populations.

The research should involve collection and dissemination of survey data, development of analytical methods for estimating behavioral relationships from these data, and forecasting the effect of development and regulatory policies on demographic variables.

Demographic studies are an example from the social sciences of what in IGBP planning are called "process studies." Research combining the talents of sociologists, anthropologists, economists, and other social scientists will be needed to understand the interactive processes that determine population characteristics over time. In the early years, this research might focus primarily on localized case studies, but international cooperation in choosing sites of the case studies and in standardizing their design and execution would be essential to the eventual generalization of the results so that they can be integrated into global forecasting.

b. The Interaction of Population, Economic Growth, Technology, and Resource Use

Research should also be initiated on the interaction among population characteristics, economic growth, and technology as they affect long-term changes in land, water, and other resource use. Human uses of land, water, air, energy and other resources now have large effects on the biogeochemical cycles that IGBP seeks to understand.

With 10 percent of the Earth's land area already under cultivation and more than 30 percent under some form of human management, land, water, and air and energy use are directly relevant to the greenhouse effect, deforestation, possible soil degradation, desertification, extinction of plant and animal species, and other global-level phenomena. Effects of land, water, and air use on the geosphere and biosphere are likely to intensify with population growth and with further agricultural and industrial development.

Land use can illustrate possible approaches to studies in this area. Consider, for example, the relationship between soil productivity and climatic change. Agricultural soils at any point in time reflect the climatic history of the area and its agricultural history. Agricultural land use in turn is affected by existing soils. If a climatic change occurs, this may directly affect the soil over time. Furthermore, as agriculture attempts to adapt to the change in climate and related changes such as soil effects, it may well cause further changes in the soil. Understanding the effects of climatic change on soils thus requires that a complex set of interrelationships between natural and social variables be studied.

Fortunately, thanks to studies by economists, geographers, lawyers, and other social scientists, a great deal is known about land use. There is a well-developed theoretical basis for research on land use and a substantial body of empirical work to draw on as well. The allocation of land depends on demographic variables: population size, characteristics such as age

composition, and degree of concentration in cities, towns and rural areas. It also depends on economic variables including per capita income, income distribution across the population, agricultural and other prices, and the tastes and preferences of the population. Technology affects and sets boundaries on how population characteristics and economic variables interact. Finally, institutions as they affect ownership and land use regulatory systems, along with public policies in such areas as agricultural subsidies are also important. Different institutional systems will lead to different patterns of land use even when demographic, economic, and technological factors are constant.

Three sources of data on land use allocation are potentially useful. First, many historical data exist. Second, remote sensing opens up the possibility of global-level data on land use. Particularly as time series are accumulated, remote sensing creates the prospect of a whole new generation of land-use studies that would have been impossible in the past. Third, a system of Biosphere Observatories has been proposed as part of IGBP. As presently conceived, they would focus on various geosphere-biosphere observations over an area of perhaps 100 square kilometers. These observatories could also serve to gather data on human activities, including land use, over time and would provide a data base useful for cross-national comparisons. Similar studies of air and water use would be useful.

At the next higher level of analysis, studies of land, water, and air use will need to be integrated, rather than viewed in isolation. We know that climate change may affect precipitation patterns; this in turn may affect land use; land-use changes often affect water use; land and water use changes may affect the atmosphere; and changes in atmospheric inputs may impact back on climate. It is through air, land, and water use that the economy interacts most directly with the geosphere-biosphere, but underlying these effects are all sorts of economic relationships and legal relationships that could be profitably studied.

Finally, if IGBP and related studies of the social dimensions of resource use are to lead to public policies that foster more rational resource use, further research should investigate the economic and social costs and benefits of avoiding environmental degradation and mitigating its effects. Clearer understanding of such costs and benefits could be particularly important in addressing management of potentially irreversible environmental changes such as depletion of the ozone layer or greenhouse gas production and associated climate change.

4. Assessment and Perception of Environmental Change

How government officials, planners, and publics perceive and respond to global environmental changes will determine how we respond to such changes. Policy makers must recognize the presence of such changes and their causes before the analyses needed to initiate policy responses and to mount appropriate programs will be undertaken. Given different economies and political systems, it is unlikely that new programs to respond to these changes will be successful until members of various economic sectors and the publics are aware and concerned about the changes. Understanding awareness and perception, in short, is a prerequisite for the effective management of global environmental change. Research which monitors and seeks to understand awareness and perception of environmental issues should be a major component of an international research program on the human dimensions of global change.

The workshop developed a matrix to structure such research. The matrix provides a way to summarize the major variables in the study of assessment and monitoring of human perceptions and reactions to a variety of global environmental changes. It is not a master design for a single study or a group of studies; its purpose is to facilitate the construction and comparison of a variety of empirical investigations and to allow the formulation of specific hypotheses and the analysis of specific cases.Use of such a matrix will encourage standardization of research

definitions, measurements and methods in different places and by different investigators. This parallels the standardization that is occurring in IGBP.

The matrix (see Figure 1) consists of two classes of parameters, a large and open set of background factors, and four classes of indicators. The design is open and can be expanded to include additional variables.

Figure 1
Matrix for Assessment and Perception Studies

BASIC PARAMETERS	BACKGROUND FACTORS	INDICATORS			
		Objective Conditions	Perceptions and Knowledge	Attitudes	Behavior
POPULATIONS					
elites vs. non-elites	Age				
core/periphery	Sex				
developing vs. developed	Class				
	Urban/Rural				
TIME					
t	Age				
t + 1	Sex				
t + 2	Class				
	Urban/Rural				

The two major parameters are time and populations. It is essential to sample many different time periods and many different populations; for example, different countries, elites versus the general public, and experts versus novices.

Many background factors are of interest and importance: age, sex, education level, socio-economic class, values, and beliefs are among them.

Finally, there are four major classes of indicators or measurements: (1) objective conditions; (2) perception and knowledge; (3) attitudes; and (4) behavior. The first type refers to objective scientific measurements of basic conditions, such as the incidence of various pollutants in the atmosphere; water levels; or rates of deforestation. The second class of indicators includes awareness of these objective conditions and views as to their implications. Among experts these later views might be cast as formal risk assessments; in general mass populations they would involve somewhat vaguer views of potential danger or lack thereof. The third set of indicators refers to people' attitudes and values regarding both specific and general environmental concerns, including tradeoffs with other common aspirations such as economic growth. The fourth set of indicators is behavioral, referring to people's actions in response to environmental issues. If a study were done with common citizens, an example of such behavior might be whether the individual disposes of family wastes in compliance with civic regulations, or ignores them. If a study were conducted of political leaders, these behaviors might include support or opposition to environmental legislation.

Thus, indicators of the first and fourth types connect people to the natural environment, and the second and third indicators are the subjective mediating factors that control this impact. The most general hypothesis implied by the matrix, although still testable, is that environmental behaviors in the last column cannot be predicted at satisfactory levels from information about objective conditions (column 1) taken alone, but will be significantly enhanced by information about perceptions and attitudes.

Many other more specific hypotheses can be suggested by measures in various regions of the matrix. Some examples follow.

If one matched the individual's perceptions of environmental facts (column 2) with the objective facts (column 1), one could create a further variable, "accuracy of perception." Such a variable should increase with other measures of environmental awareness or tests of knowledge. This cluster of measures may also vary with:

- Proximity of the individual to the environmental damage; for example, living near toxic waste;
- Exposure to mass media;
- Education;
- Variety of life experiences; for example, living in one place for one's whole life versus different residential experiences; and,
- Age.

Attitudes about the importance of environmental protection vary by:

- Self-interest; for example, fishermen dependent on clean water;
- Other attitudes, such as the felt importance of economic growth;
- Deeper values such as the disposition to save or defer consumption; or,
- Attitudes toward risk, which may in turn depend on:
    * Personality factors such as optimism and pessimism; and,
    * Differences in structural location: more protective attitudes about the environment may exist among workers in state-owned enterprises than in private ones.

In addition, other kinds of hypotheses can be formed by other second-order combinations or codings of variables in the matrix. For example, one might subdivide environmental conditions into different groups. Such groups might include: (1) highly visible conditions such as desertification or water pollution; (2) less visible conditions such as slow changes in climate; and (3) least visible risks like radiation or ozone depletion. Then it might be hypothesized that

many first-order relationships across the whole matrix might be stronger or weaker depending on hazard visibility. As an obvious example, awareness of invisible risks may be much more dependent on mass media use than is awareness of more visible risks.

Or again, one might hypothesize that blue-collar workers may be limited in their awareness of risks to those found in their own work places, while national and global risks are more likely to be perceived by intellectuals.

Exploring these several issues would improve the ability to understand the relationships between objective conditions and behavior toward the environment. It would be a major step toward ascertaining how the political will can be found to cope with environmental problems.

A parallel line of research should focus on danger or transitional areas, concentrating on environmental hazards, awareness of these hazards, and their management. Such case studies could integrate the various topics addressed during the workshop: social dimensions of resource use; the impact of institutional mechanisms on the environment; and, assessments and perceptions of environmental change. This research would involve a five-stage effort.

- The first stage would be the identification and mapping of high danger zones in global change. These are places where the effects of global environmental change are concentrated and where they threaten the long-term sustainability of the Earth.

- The second stage would be to select a sample of these danger zones from different parts of the world and study how the environmental threats have developed in each of the cases over the past several decades. This would involve examining and then comparing the processes of environmental change and their effects, and the connection with globally occurring changes.

- The third stage would involve analyses of how the environmental changes have been perceived in each of the danger zones, how attitudes have evolved toward these changes, and the behaviors that have occurred.

- The fourth stage would involve analyses of the coping and management responses, both individual and collective, that have occurred, and the effects that these responses have had on the trends of environmental changes.

- The final stage would be to assess the studies and draw implications for improving strategies for monitoring and responding to global environmental change.

While the framework and studies proposed may not provide definitive answers to how differing population groups at different times and places have perceived and assessed environmental changes, they should provide an important starting point for research that is comparative and, at least potentially, cumulative.

5. Impact of Institutional Mechanisms on the Environment

As evidence accumulates on the relationship between global changes and human activities, scientific and political institutions have begun to react, intensifying research on environmental impacts and raising basic policy questions — "How serious are the risks? What should we do to avert them?"

Responding to a United Nations call, the World Commission on Environment and Development, commonly known as the Bruntland Commission, in its report, Our Common

Future,[6] underlined the need for national and international policies that would encourage environmentally sustainable economic growth. Discussions in the Chinese – U.S. workshop of silting, deforestation, desertification, and water pollution conveyed a sense of urgency concerning environmental problems. Yet underlying this concern was an assumption, common to the participants, that the pace and extent of humankind's environmentally destructive activities can be reduced by conscious governmental action. Governments may or may not be able to change policies that accelerate environmental degradation or to adopt measures that reduce it. The extent to which they succeed could play an important role in understanding and managing the human aspects of global change.

Social science research concerning the interrelationship between institutions broadly defined and environmental change has a dual function. Research on institutions can (a) help estimate the probability that such mechanisms will increase or reduce activities that threaten the geosphere-biosphere, and can (b) provide a knowledge base that may facilitate the implementation of sensible and effective policies.

a. Why Study Institutions?

All institutional mechanisms that facilitate technological and economic development contribute to human impacts on the geosphere and biosphere. Had human beings not created the economic, governmental, and scientific institutions that led to modern methods of agricultural and industrial production, transportation, and heating, or medical science, or programs of sewage disposal, water treatment, and public health, then human populations would have remained small and predominantly pastoral, and their impact on the environment would be minimal. One might, therefore, view all economic and governmental institutions that facilitate economic growth and reduce mortality as affecting global change.

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6. World Commission on Environment and Development, Our Common Future (New York: Oxford, 1987).

Human societies are not likely to abandon the search for economic growth and well-being. The relevant research problem, therefore, concerns the search for environmentally "sustainable" economic growth; that is, for paths of economic growth that do not wreak global environmental changes which diminish opportunities, now and in the future, for health and prosperity. From this perspective, research is needed on the effects on the global environment of policies, laws, institutions and implementation techniques. Which institutional mechanisms, in their methods of structuring economic activity, encourage needlessly destructive uses of land, water, and other resources? Which institutional mechanisms promote environmentally sustainable economic growth?

One important topic embedded in these questions is the role of market incentives as opposed to direct governmental controls in setting prices and allocating uses of land, water, forests and other resources. What are the consequences for the global environment of current trends toward relaxation of governmental controls and use of market mechanisms? The answers are by no means obvious.

The use of market incentives to increase productivity can lead to some forms of water and air pollution. On the other hand, markets can create incentives to prevent waste and to promote improvements in environmental quality; timber pricing and forest leasing practices as they relate ultimately to deforestation and desertification could be an interesting case to study.

These observations led workshop participants to suggest the desirability of research that would involve a multi-country inventory of governmental laws and policies concerning the pricing of natural resources and manufactured products, and methods of allocating access to land, water, forests, grazing-land, and other resources. The goal would be to identify the prevalence and impact of laws and institutions that encourage waste and pollution in ways that market incentives might avoid.

Important questions were raised in the workshop about the environmental impact of international trade and foreign investment policies. Do trade and investment policies that encourage the spread of multi-national business enterprises: (a) accelerate the diffusion of advanced pollution control and resource-management techniques; or, (b) redistribute environmental degradation to less developed countries and accelerate local resource depletion and environmental erosion? The answers are likely to be complex and differentiated, suggesting the desirability of cross-national research comparing the practices of multi-national corporations and local enterprises in the same industry. Similar research questions might be raised concerning the environmental impact of national and international commodity pricing regimes and debt repayment rules, which under some circumstances may encourage environmentally-harmful agricultural, forestry and water-use policies.

In the last twenty years, there has been a dramatic increase in national laws designed to restrict air and water pollution, protect endangered animals, regulate use and disposal of toxic chemicals, and prevent deforestation. Because enforcement agencies rarely are adequately staffed, implementation of environmentally significant legislation is almost always problematic. Nevertheless, in many countries there has been significant progress in enforcing certain laws, suggesting that governmental institutions are capable, under some circumstances, of curtailing adverse human impacts on the geosphere and biosphere. The important research questions are which kinds of regulatory interventions are most successful and under which circumstances. Which social arrangements, political institutions, and implementation strategies promote successful management of human activities important to global change?

Building on a growing literature of historical and comparative studies of environmental law enforcement, further cross-national research is needed concerning the institutional arrangements that facilitate enactment of regulatory legislation, and why approaches to implementation vary in effectiveness. Such studies might compare countries at different levels of

economic growth as well as those at similar levels. They should include observation of field-level enforcement practices and surveys of regulated enterprises, as well as utilization of standard documentary sources. And they should assess both obstacles to effective enforcement and techniques for overcoming them.

National-level comparative studies might ask questions such as these. To what extent does effective implementation depend on such factors as: (a) intensive governmental monitoring and data-gathering; (b) non-governmental monitoring mechanisms, such as environmental advocacy organizations and aggressive coverage of environmental issues by television and print journalists; or, (c) the voice of citizens' rights groups in bringing lawsuits against violators and enforcement agencies?

Studies at the international level should address such questions as:.

1. What are the implications of the diffusion of industries for global environmental change?
2. What factors place global change issues on the international political agenda?
3. What are the international legal and institutional strategies for coping with such issues as the effects of fossil fuel consumption, the consequences of the emission of "greenhouse gases," species conservation, and deforestation?
4. What international strategies are likely to be effective and enforceable?
5. What are the likely impacts of these strategies on international trade and economic growth?
6. How can international institutions and laws cope with global environmental problems that are not within the scope of national boundaries but are instead in the oceans and outer space?

Many environmental factors — such as emissions that lead to acid precipitation, production of chlorofluorocarbons that affect the ozone layer, deforestation, species destruction, fossil fuels consumption that might lead to global warming — obviously have effects that extend beyond national boundaries. Obtaining international cooperation to address global environmental issues

poses special problems. For example, how can non-crisis, incrementally-developing, global change command sufficient attention to ensure appropriate international action? The uneven distribution across countries of scientific expertise and information at best slows the development of common understandings about these problems. What mechanisms work to diffuse information rapidly and to insure its credibility?

Based on past experience in the environmental field and others, what models or strategies are available for international and global cooperation on global change issues, and which are likely to be effective? How can countries be induced to take action involving some costs to themselves when their acting makes only a modest contribution to solving the problem and their refusing to do so could be costless because others might take on the burden of collective action? Differential levels of economic growth and wealth sharpen the dilemma. Many scholars believe that international cooperation depends on there being a dominant state that will bear a disproportionate share of the cost of obtaining collective goods such as environmental protection, but what if no country is in a position or willing to do this?

Considering various international strategies for controlling "greenhouse gases" — national emissions quotas, emissions taxes, mandatory process controls — what implementation difficulties does each strategy entail, and what is its likely impact on international trade and economic growth? Under what circumstances are countries likely to agree to and abide by treaties that require costly technological or economic adaptations? In this regard, what modes of sharing compliance or adaptation costs, including subsidies or different standards, for less wealthy countries are feasible?

b. Governmental Capacity

The capacity of governments to respond adequately to environmental problems cannot be taken for granted. Given the pressures on national governments to solve pressing economic and social problems, to ensure national security, global changes may receive a lower priority, even if deemed urgent by many.

Can we then predict institutional responses to global environmental changes? Do we know to what extent the capacity of government to respond is affected by population growth, economic growth, and the structure of international trade and finance? What role will political structure, political party relationships, degree of state ownership of production enterprises and natural resources, the structure of mass media, and institutional arrangements affecting the role of scientists in government play in government decision making on issues of global change?

It might be useful to adopt a case study approach in analyzing governmental responses to major, dramatic environmental crises of the magnitude of the Bophal explosion in India, the escape of radiation from the Chernobyl nuclear reactor in the U.S.S.R., or the discovery of toxic poisoning of Japanese citizens near Minimata Bay. How do governmental responses to such rapid environmental changes compare to more incremental, long-term, irreversible, global processes? Without such research, there can be no realistic understanding of the potential for effective governmental action with respect to global change.

6. Conclusion

Subjects covered in the three broad areas clearly overlap. For the results of all the separate studies possible under these areas to fit together, it is essential to forge linkages between them. The participants in the workshop realize that this list of topics is not comprehensive. We are convinced, however, of the importance of these topics and of their essential contribution to any international research program on the human dimensions of global change, and to the study of the Earth system on a global scale.

The workshop strongly urges that an international research program on the human dimensions of global environmental change be launched. Further, the workshop participants urge Chinese and American authorities to seek support for research on this important element of global change, the human dimension.

Appendix

Participants in the Chinese-U.S. Workshop on the Human Dimensions of Global Environmental Change

12-16 May 1988

Peking University

Beijing

China

Chinese Participants

Professor Tang Xiaoyan, Director of Center of Environmental Sciences, Peking University

Professor Chen Changdu, Center of Environmental Sciences, Peking University

Professor Zhou Erliu, Vice President of Peking University, Director of the Institute of Sociology

Professor Ye Duzheng, Chairman China's National Committee for IGBP, The Chinese Academy of Sciences

Professor Chen Jingsheng, Department of Geography, Peking University

Associate Professor Cheng Zhengkang, Center of Environmental Sciences, Peking University

Associate Professor Gao Guanmin, Department of Environmental Sciences, Wuhan University

Dr. Gu Baochang, Department of Sociology, Peking University

Professor Guan Boren, Center of Environmental Sciences, Peking University

Professor Jiang Meiqiu, Department of Sociology, Peking University

Ms. Li Huiming, Lecturer, Department of Economics, Nankai University

Mr. Li Qiang, Lecturer, Department of Sociology, People's University of China

Professor Lu Zhuoming, College of Economics, Peking University

Dr. Ma Rong, Department of Sociology, Peking University

Associate Professor Ni Shaoxiang, Department of Geo and Ocean Sciences, Nanjing University

Associate Professor Ouyang Xin, Institute of Environmental Law, Wuhan University

Associate Professor Shen Decan, Department of Psychology, Peking University

Mr. Song Junling, Beijing Academy of Social Sciences

Professor Wang Songpei, Director of the Institute for Rural Development,The Chinese Academy of Social Sciences

Mr. Zhang Zhifei, National Foundation of Natural Sciences

Dr. Zeng Yi, Institute of Demography, Peking University

U. S. Participants

Professor Harold K. Jacobson, Director, Center for Political Studies, The University of Michigan

Ms. Alice Hogan, Senior Program Manager for China, National Science Foundation

Professor Richard Bishop, Department of Agricultural Economics, University of Wisconsin

Professor William C. Clark, John F. Kennedy School of Government, Harvard University

Professor Philip E. Converse, Director, Institute for Social Research, The University of Michigan

Dr. Roland J. Fuchs, Vice Rector, United Nations University

Professor Robert Kagan, Department of Political Science, University of California, Berkeley

Professor Roger Kasperson, Department of Geography, Clark University

Professor Michael Oksenberg, Center for Chinese Studies, The University of Michigan

Professor T. Paul Schultz, Department of Economics, Yale University

Ms. Barbara Boyle Torrey, Chief, Center for International Research, Bureau of the Census

Professor Amos Tversky, Department of Psychology, Stanford University

Professor Edith Brown Weiss, Georgetown University Law Center, Georgetown University